



Landsat 7 Processing System (LPS)

System Requirements Review

October 6, 1994

IPD
Code 560

LPS System Requirements Review



Purpose of Review

- **Obtain Approval for LPS Functional and Performance Specifications**
- **Obtain comments from the Technical Review Panel**



Agenda

- **Introduction**
- **System Concept**
- **System Requirements**
- **Functional Requirements**
- **Performance Requirements**
- **Management Topics**



Background

Formerly

- **Joint NASA/DoD development team**
- **Two instruments: ETM+ and HRMSI**
- **Wideband data downlink via TDRSS**

Currently

- **NASA development team**
- **Operations managed by NOAA**
- **Two instruments: ETM+ and LFO**
- **Wideband data direct downlink to EDC at Sioux Falls, SD**



LPS design goals are to:

- **Maximize System throughput (> 7.5 Mbps)**
- **Provide maximum functionality within allotted budget**

To accomplish these goals LPS must:

- **Exploit performance of RISC based CPUs**
- **Incorporate parallel processing where appropriate**
- **Obtain refined code estimates through prototyping**
- **Investigate COTS and custom solutions for high rate disk capture**

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Introduction



Documentation

DOCUMENT	STATUS				COMMENTS
	DRAFT	BASELINE	FINAL	SIGNED-OFF	
Landsat 7 System Specification	X	11/02/94			GSFC Doc. No. 430-L-0002-A
Landsat 7 System and Operations Concept	X	10/13/94			GSFC Doc. No. 430-11-06-003-0
Data Format Control Book(DFCB) Volume 4 - Wideband Data	X	8/26/94			MMAS Doc. No. 23007702
ECS TO LANDSAT 7 IRD	6/94				HAIS Doc. No. 194-219-SE1-003
LPS Functional and Performance Specifications	X	9/26/94			GSFC Doc. No. 560-8FPS/0194
LPS Operations Concept	X	9/27/94			GSFC Doc. No. 560-3OCD/0194
LGS to LPS ICD	X	1/30/95			GSFC Doc. No. 560-1ICD/0794

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Introduction



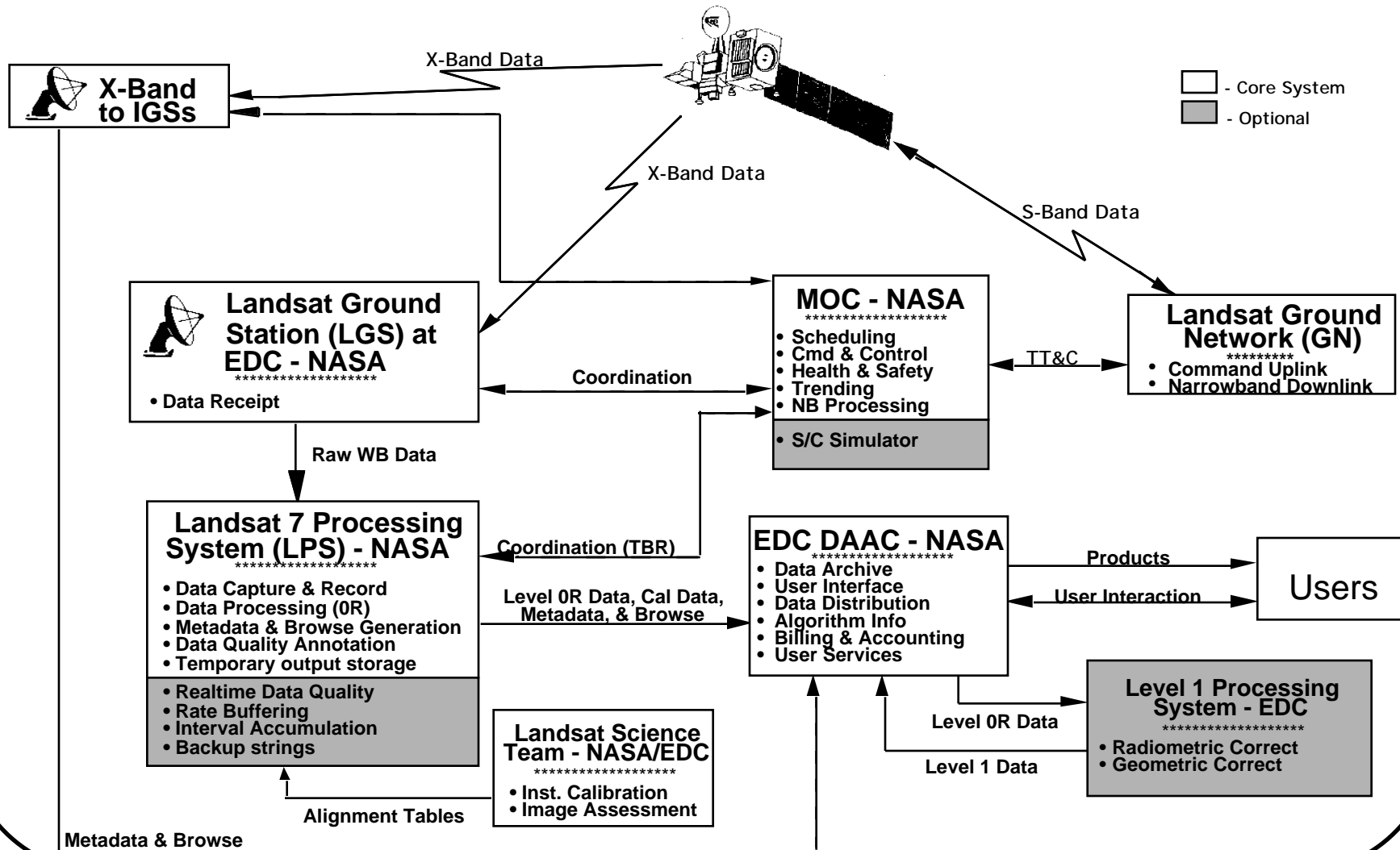
Documentation Tree



- Introduction
- **System Concept**
- System Requirements
- Functional Requirements
- Performance Requirements
- Management Topics



L7 Ground System Overview





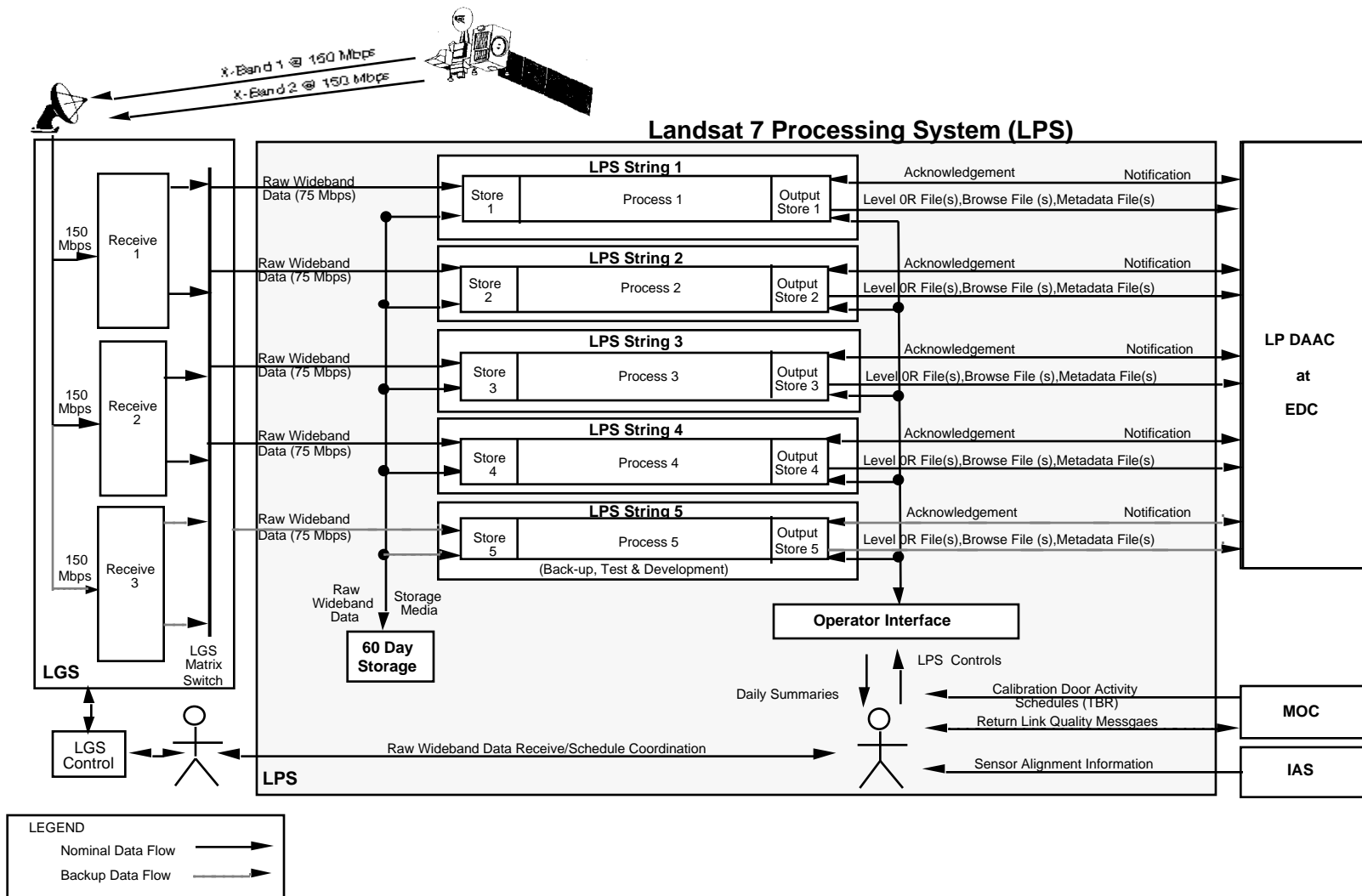
External Interfaces

- **LGS**
Coordinate with LGS to capture wideband data on contact basis
Receive wideband data at 75 Mbps on four physical channels

- **MOC (TBR)**
Receive Calibration Door Schedules
Provide non-nominal return link quality statistics via voice

- **IAS**
Receive Sensor Alignment Tables via hardcopy
Receive anomalous image quality statistics via voice

- **LP DAAC**
Notify LP DAAC of data availability
Receive transfer status from the LP DAAC





Contact/Downlink characteristics

- **5-6 contacts per day**
- **2 groupings of contacts per day with maximum of three back to back contacts**
- **2 X-band direct downlinks to LGS at 150 Mbps each (1 realtime and 1 playback)**
- **LGS generates four 75 Mbps physical channels which are forwarded to the LPS simultaneously**

Capture and Throughput Requirements

- **Receive 4 input bit serial data streams**
- **All data is post-pass processed**
- **Processing data rate 7.5 Mbps for each input**
- **Raw data is stored on tape for 60 days**
- **Data volume is the equivalent of 250 Landsat 7 ETM+ scenes**



Architecture

- **LPS consists of five functionally independent processing strings:**
 - **Four primary strings, one for each 75 Mbps physical channel from LGS**
 - **One backup string also used for development and testing**

Security

- **Utilize security functions provided by COTS systems**
- **Facility level security provided by EDC**



Sub-intervals

Interval: The time duration between the start and stop of an imaging operation (observation) of the Landsat 7 ETM+ instrument.

Sub-Interval: A segment of raw wideband data interval received during a Landsat 7 contact period. Sub-intervals are caused by breaks in the wideband data stream due to communication dropouts and/or the inability of the spacecraft to transmit a complete observation (interval) within a single Landsat 7 contact period.



LPS Output Files (per string)

- **Level 0R files**

Instrument data files - Each file contains image data from single band in a single subinterval. Data nominally aligned using fixed and predetermined integer values

Calibration files - One file created per subinterval. Contains Calibration data received on a major frame basis.

Mirror Scan Correction files - One file created per subinterval. Contains scan error and scan direction data

PCD (Payload Correction Data) files - One file created per subinterval. Contains Payload Correction Data for the subinterval



LPS Output Files (cont.)

- **Metadata file**
One file created per subinterval. Contains data quality and accounting information, cloud cover assessment, and scene identification information for the subinterval
- **Browse Image Files**
One monochrome (image from a single band) file and one multiband (image from three predefined bands) file created per subinterval. Contains reduced size scenes of the full size scene data contained in the Level 0R instrument data files.



Quality and Accounting Data

- **Return Link Quality and Accounting Data**

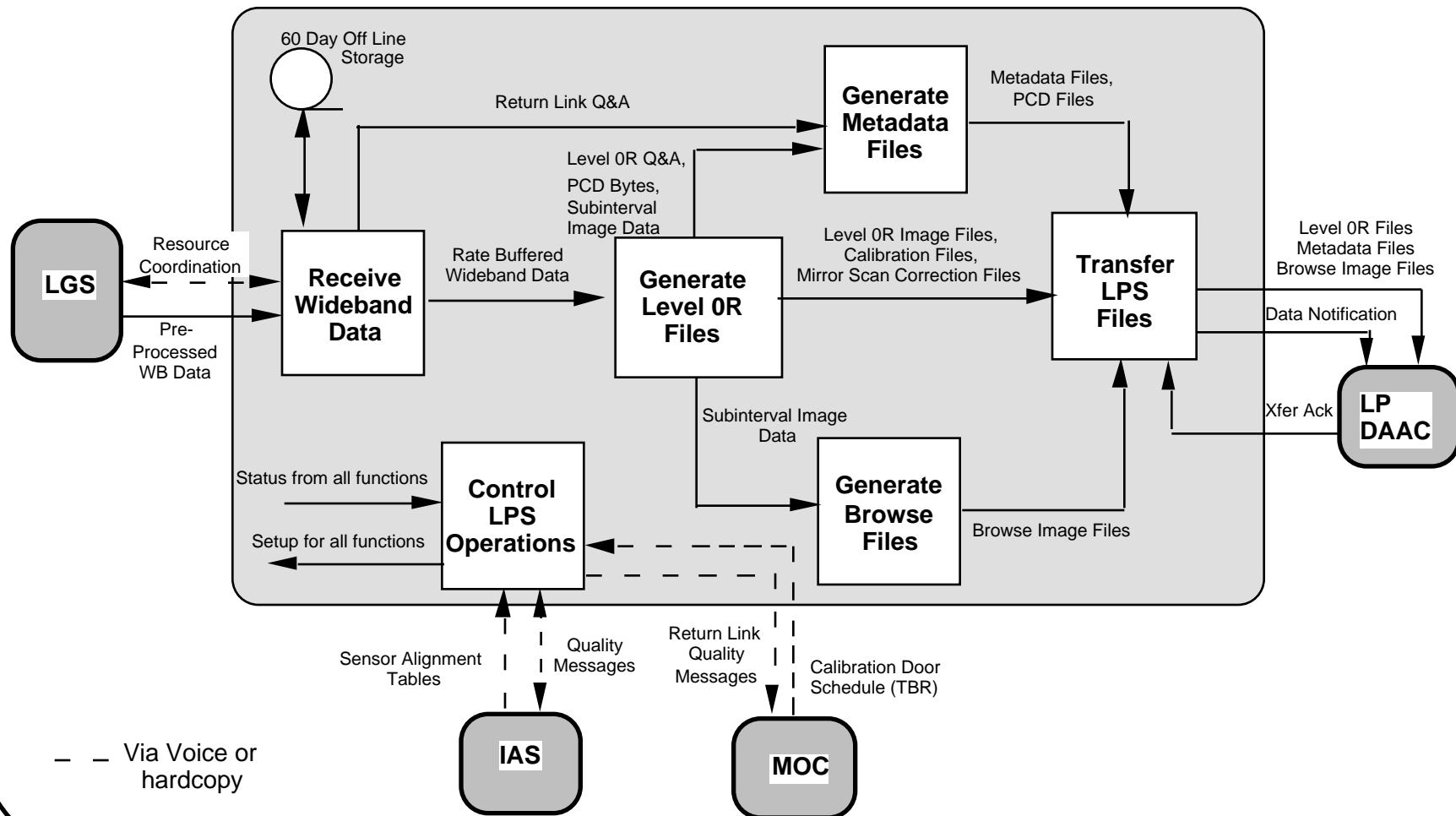
Data quality and accounting information collected by LPS from CCSDS Grade 3 and BCH error detection and correction processing.

- **Level 0R Quality and Accounting Data**

Data quality and accounting information collected by the LPS, on a subinterval basis, from processing of the ETM+ major frames.



LPS Functional Diagram





LPS Functions

- **Receive Wideband Data**

- Capture data in Realtime from the LGS**

- Provide wideband data storage on removable media for 60 days**

- **Generate Level 0R files**

- Perform CCSDS AOS Grade-3 service**

- Perform Frame synchronization**

- Perform PN Decoding**

- Perform BCH Error Detection and Correction**

- Generate Return Link Quality and Accounting**

- Perform ETM+ Major Frame Synchronization**

- Deinterleave and Reverse Bands**

- Align Bands (Integer-Pixel Alignment)**

- Determine Subintervals**

- Generate Level 0R Quality and Accounting**



LPS Functions (cont.)

- **Generate Browse Images**
- **Generate Metadata files**
 - Process Payload Correction Data (PCD)**
 - Perform Automatic Cloud Cover Assessment**
 - Identify Scenes**
- **Transfer LPS Files**
 - Provide data available notification to the LP DAAC**
 - Receive Transfer Acknowledgments from the LP DAAC**
- **Control LPS Functions**
 - Receives Operator Inputs**
 - Receive Status Information from other LPS functions**
 - Display/Print collected information upon request**
 - Generate messages and alarms for operators**



- Introduction
- System Concept
- **System Requirements**
- Functional Requirements
- Performance Requirements
- Management Topics



System Level Functional Requirements

- 3.1.1 LPS shall provide the capability to support operations 24 hours per day, 7 days per week, on a continuous basis.**
- 3.1.2 LPS shall provide the capability to support Landsat 7 operations for a minimum mission life of 5 years.**
- 3.1.3 LPS shall provide the capability to receive, process and deliver LPS output files for 4 wideband data inputs simultaneously from the LGS.**
- 3.1.4 LPS shall process wideband data inputs from LGS on a Landsat 7 contact period (return link wideband data recording session) basis.**
- 3.1.5 LPS shall process wideband data to generate LPS output files on a received sub-interval basis.**
- 3.1.6 LPS shall provide the capability to generate Landsat 7 return link quality and accounting data on a Landsat 7 contact period basis for each wideband data input.**
- 3.1.7 LPS shall provide the capability to generate Level 0R quality and accounting data on a sub-interval basis for each LPS wideband data input.**



System Level Functional Requirements (cont.)

- 3.1.8 LPS shall provide the capability to reprocess wideband data.**
- 3.1.9 LPS shall provide an orderly system start-up capability.**
- 3.1.10 LPS shall provide an orderly system shut-down capability.**
- 3.1.11 LPS shall provide the capability to control LPS operations.**
- 3.1.12 LPS shall provide the capability to monitor LPS operations.**
- 3.1.13 LPS shall provide the capability to generate and report LPS error messages.**
- 3.1.14 LPS shall provide the capability to configure system resources to support LPS operations (with normal or fall-back configurations).**
- 3.1.15 LPS shall provide the capability to isolate system faults.**
- 3.1.16 LPS shall provide the capability to recover from system faults.**



System Level Functional Requirements (cont.)

- 3.1.17 LPS shall provide the capability to test LPS functions and external interfaces.**
- 3.1.18 LPS shall provide the capability to execute diagnostic tests for verifying proper operation of system capabilities and components.**
- 3.1.19 LPS shall provide monitoring test points and indicators to verify proper operation of system capabilities and components.**
- 3.1.20 LPS shall provide the capability to support software maintenance during LPS normal operations on a non-interruptive basis.**
- 3.1.21 LPS shall permit corrective maintenance to be performed on failed equipment while the remainder of the system is actively satisfying mission critical functions not supported by that equipment.**
- 3.1.22 LPS shall provide the capability to support preventive maintenance during LPS normal operations on a non-interruptive basis.**
- 3.1.23 LPS shall provide the capability to support operator training during LPS normal operations on a non-interruptive basis.**



External Interface Requirements

3.2.1* LPS shall interface with Landsat 7 Ground Station (LGS) to receive wideband data.

3.2.2* LPS shall interface with LP DAAC to coordinate the transfer of LPS output files to Land Processes Distributed Active Archive Center (LP DAAC) .

3.2.3* LPS shall interface with Mission Operations Center (MOC) .

3.2.4* LPS shall interface with Image Assessment System (IAS) .



System Level Performance Requirements

- 4.1.1 LPS shall provide the capability to receive and process a maximum of 5 wideband inputs from LGS.**
- 4.1.2 LPS shall provide the capability to simultaneously receive and process any 4 of the 5 wideband inputs to support LPS operations .**
- 4.1.3 LPS shall provide the capability to receive and process the equivalent of 250 Landsat 7 ETM+ scenes of wideband data per day (approximately 100 GB per day).**
- 4.1.4 LPS shall provide the capability to receive and process the daily volume of wideband data within 16 (TBR) hours of its receipt at LPS.**
- 4.1.5 LPS shall provide the capability to reprocess a maximum of 10 percent of the daily input volume of wideband data (approximately 25 scenes or 10 GB per day).**
- 4.1.6 LPS shall provide the capability to process received wideband data at an average aggregate rate of 12 Mbps (TBR - Includes 10% of overhead due to reprocessing).**



System Level Performance Requirements (cont.)

4.1.7 LPS shall provide a minimum of TBD hours of on-line storage for temporary retention of LPS files.

4.1.8 LPS shall introduce no more than one bit error in 10^{9} bits.**

4.1.9 LPS shall maintain data processing throughput performance for all Landsat 7 raw wideband data received with a bit error rate (BER) of one bit error in 10^{5} bits.**



Reliability, Maintainability, and Availability Requirements

- 4.4.1 LPS shall provide an Operational Availability (Ao) of 0.96 or better for all processing functions.**
- 4.4.2 LPS shall support a mean time to restore (MTTRes) capability of 4 hours or better.**
- 4.4.3 LPS MTTRes shall not exceed twice the required MTTRes in 99 percent of failure occurrences.**



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Receive Wideband Data

3.3.1.1 LPS shall provide the capability to receive return link wideband data inputs from LGS on a Landsat 7 contact period basis.

3.3.1.2 LPS shall provide the capability to receive return link wideband data inputs from LGS on an LGS output channel basis.

3.3.1.3 LPS shall provide the capability to retain return link wideband data on a Landsat 7 contact period basis.

3.3.1.4 LPS shall provide the capability to retain return link wideband data on an LGS output channel basis.

3.3.1.5 LPS shall provide the capability to retrieve retained return link data on a Landsat 7 contact period basis.

3.3.1.6 LPS shall provide the capability to retrieve retained return link wideband data on an LGS output channel basis.



Receive Wideband Data (cont.)

3.3.1.7 LPS shall provide the capability to record return link wideband data to removable storage media, on a Landsat 7 contact period basis.

3.3.1.8 LPS shall provide the capability to save removable storage media recorded with return link wideband data.

3.3.1.9 LPS shall provide the capability to retrieve return link wideband data from removable storage media.

3.3.1.10* LPS shall generate an LPS wideband data receive summary for each Landsat 7 contact period.

3.3.1.11 LPS shall coordinate the receipt of return link wideband data with LGS.

3.3.1.12* LPS shall prevent the loss of return link wideband data receive capability due to the receipt of data at rates exceeding the LPS performance requirements .

3.3.1.13 LPS shall coordinate resolution of all data transfer problems with LGS.



Generate Level 0R Files

3.3.2.1* LPS shall perform CCSDS AOS Grade-3 service on all received wideband data.

3.3.2.2 LPS shall perform Channel Access Data Unit (CADU) synchronization on all received wideband data.

3.3.2.3 LPS shall provide the capability to detect and synchronize on normal and inverted polarity wideband data.

3.3.2.4* LPS shall utilize a Search/Check/Lock/Flywheel strategy for synchronization.

3.3.2.5 LPS shall provide the capability to invert the bits of each CADU detected to have inverted polarity.

3.3.2.6 LPS shall provide the capability to correct bit slips, selectable between 0 and plus or minus 3 bits, in a CADU, by truncating or padding to the proper length.

3.3.2.7* LPS shall provide the capability to perform pseudo-random (PN) decoding of all received VCDUs



Generate Level 0R Files (cont.)

3.3.2.8 LPS shall provide the capability to store all CADUs which have failed CCSDS Grade-3 service processing, on a Landsat 7 contact period basis.

3.3.2.9 LPS shall provide the capability to perform BCH error detection and correction of the VCDUs (CCSDS processed data).

3.3.2.10 LPS shall provide the capability to store all CADUs which have failed BCH error detection and correction, on a Landsat 7 contact period basis.

3.3.2.11 LPS shall provide the capability to sort VCDUs by VCIDs.

3.3.2.12 LPS shall provide the capability to delete VCDUs containing fill data.

3.3.2.13* LPS shall provide the capability to collect and store Landsat 7 return link (input) quality and accounting data for the wideband data received during each contact period:

3.3.2.14* LPS shall locate ETM+ minor frames in each received VCDU.



Generate Level 0R Files (cont.)

3.3.2.15* LPS shall perform ETM+ major frame synchronization using ETM+ minor frames.

3.3.2.16* LPS shall provide the capability to band deinterleave Format 1 ETM+ .

3.3.2.17* LPS shall provide the capability to band deinterleave Format 2 ETM+ data .

3.3.2.18 LPS shall provide the capability to reverse the order of the ETM+ scan line data received in reversed order.

3.3.2.19* LPS shall provide the capability to fill the Landsat 7 data with preselected values.

3.3.2.20 LPS shall provide the capability to extract mirror scan correction data (MSCD) on an ETM+ major frame basis.

3.3.2.21 LPS shall provide the capability to extract calibration data on an ETM+ major frame basis.

3.3.2.22 LPS shall provide the capability to perform integer-pixel alignment for each ETM+ band using sensor alignment information.



Generate Level 0R Files (cont.)

3.3.2.23 LPS shall provide the capability to determine ETM+ data sub-intervals.

3.3.2.24 LPS shall provide the capability to process wideband data to level 0R.

3.3.2.25* LPS shall provide the capability to generate correlated Level 0R file(s) on a received sub-interval basis.

3.3.2.26* LPS shall generate Level 0R quality and accounting data.

3.3.2.27 LPS shall provide the capability to correct spacecraft time using the spacecraft drift time information available in the PCD (TBR).

3.3.2.28 LPS shall provide the capability to append the VCDU Status field information to Level 0R files(s) on a major frame basis.

3.3.2.29 LPS shall provide the capability to identify the presence of calibration door activities.



Generate Browse Files

3.3.3.1 LPS shall provide the capability to generate browse data for each ETM+ image sub-interval identified by LPS.

3.3.3.2 LPS shall provide the capability to generate monochrome browse data from one predetermined band of the ETM+ scene data.

3.3.3.3 LPS shall provide the capability to generate multiband browse data from three predetermined bands of the ETM+ Format 1 scene data.

3.3.3.4* LPS shall include Sub-interval identification, Sub-interval start and stop times, Browsed data source band identification(s), and Browse processing information on the browse data generated for each sub-interval.

3.3.3.5 LPS shall provide the capability to generate browse data using a predetermined reduction factor .



Generate Metadata Files

3.3.4.1 LPS shall provide the capability to synchronize on PCD bytes for assembling PCD minor frames.

3.3.4.2 LPS shall provide the capability to fill missing PCD data.

3.3.4.3* LPS shall provide the capability to assemble PCD major frames.

3.3.4.4 LPS shall provide the capability to generate PCD file(s) on a sub-interval basis.

3.3.4.5 LPS shall provide the capability to collect and store PCD quality and accounting data on a sub-interval basis.

3.3.4.6 LPS shall provide the capability to collect and store processed PCD quality and accounting data on a sub-interval basis.

3.3.4.7* LPS shall provide the capability to perform ETM+ scene identification in accordance with the Worldwide Reference System (WRS) scheme.



Generate Metadata Files (cont.)

3.3.4.8 LPS shall provide the capability to perform automatic cloud cover assessment (ACCA) for WRS scenes.

3.3.4.9 LPS shall provide the capability to perform ACCA on scene quadrant (TBR) and full scene basis.

3.3.4.10 LPS shall use predefined comparison values in performing ACCA.

3.3.4.11 LPS shall generate Level 0R metadata (ancillary data) file(s) on a sub-interval basis.

3.3.4.12* LPS shall generate and include Level 0R metadata information in each Level 0R metadata file(TBR).



Transfer LPS Files

3.3.5.1 LPS shall notify LP DAAC on the availability of LPS files.

3.3.5.2 LPS shall coordinate with LP DAAC to transfer LPS files to LP DAAC .

3.3.5.3 LPS shall provide the capability to receive notification from LP DAAC on the successful receipt of transferred LPS files.

3.3.5.4 LPS shall provide the capability to store LPS data files until confirmation of successful transfer is received from the LP DAAC.

3.3.5.5 LPS shall provide a manual over-ride and protected capability to delete all LPS files on a specific contact period basis.

3.3.5.6 LPS shall provide a manual over-ride and protected capability to retain all LPS files on-line on a specific contact period basis.

3.3.5.7 * LPS shall provide the capability to generate LPS file(s) transfer summary on a daily basis.



Control LPS Operations

3.3.6.1 LPS shall provide the capability to generate and modify LPS set-up tables from operator inputs.

3.3.6.2 LPS shall provide the capability to collect and report Landsat 7 return link quality and accounting data for each wideband data input on a Landsat 7 contact period basis.

3.3.6.3 LPS shall provide the capability to collect and report Level 0R quality and accounting data for each wideband data input on a sub-interval basis.

3.3.6.4 LPS shall display and/or print quality and accounting data upon operator request.

3.3.6.5 LPS shall provide the capability to display and/or print LPS file(s) transfer summary upon operator request.

3.3.6.6 The LPS shall allow the operator to select thresholds for results and errors reported by the LPS.



Control LPS Operations (cont.)

3.3.6.7 LPS shall automatically generate messages and alarms to alert the operator of LPS results and errors exceeding selected thresholds.

3.3.6.8 LPS shall provide the capability to manually over-ride the LPS automated functions.

3.3.6.9 LPS shall provide the capability to suspend generation of LPS files.



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Functional Level Performance Requirements

- 4.3.1 LPS shall provide the capability to receive wideband data for Landsat 7 contact periods of up to 14 minutes.**
- 4.3.2 LPS shall provide the capability to retain wideband data for up to TBD hours (at least for three back-to-back contact periods) for each LGS input.**
- 4.3.3 LPS shall provide the capability to retrieve retained wideband data at rates equal to or greater than 7.5 Mbps for each LPS input.**
- 4.3.4 The LPS shall provide the capability to generate browse data with a reduction factor of 16 or better.**
- 4.3.5 LPS shall provide the capability to identify ETM+ WRS scene within an accuracy of TBD Kilometer.**



External Interface Performance Requirements

4.2.1 LGS-LPS interface shall provide the capability of transferring wideband data at a maximum rate of 75 Mbps per LPS wideband data input.

4.2.2 LPS-LP DAAC interface shall provide the capability to transfer the daily volume of LPS output files to LP DAAC within 8 hours (TBR) of their availability in LPS storage.



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Development Approach

Methodology: Classic Waterfall (Tailored SSDM)

Development Environment:

- **CASE Tools (CADRE, RTM, ICAS)**
- **operating system (unix)**
- **ANSI C, POSIX**
- **ORACLE DBMS**
- **standard communications**

Maximize use of COTS hardware and software

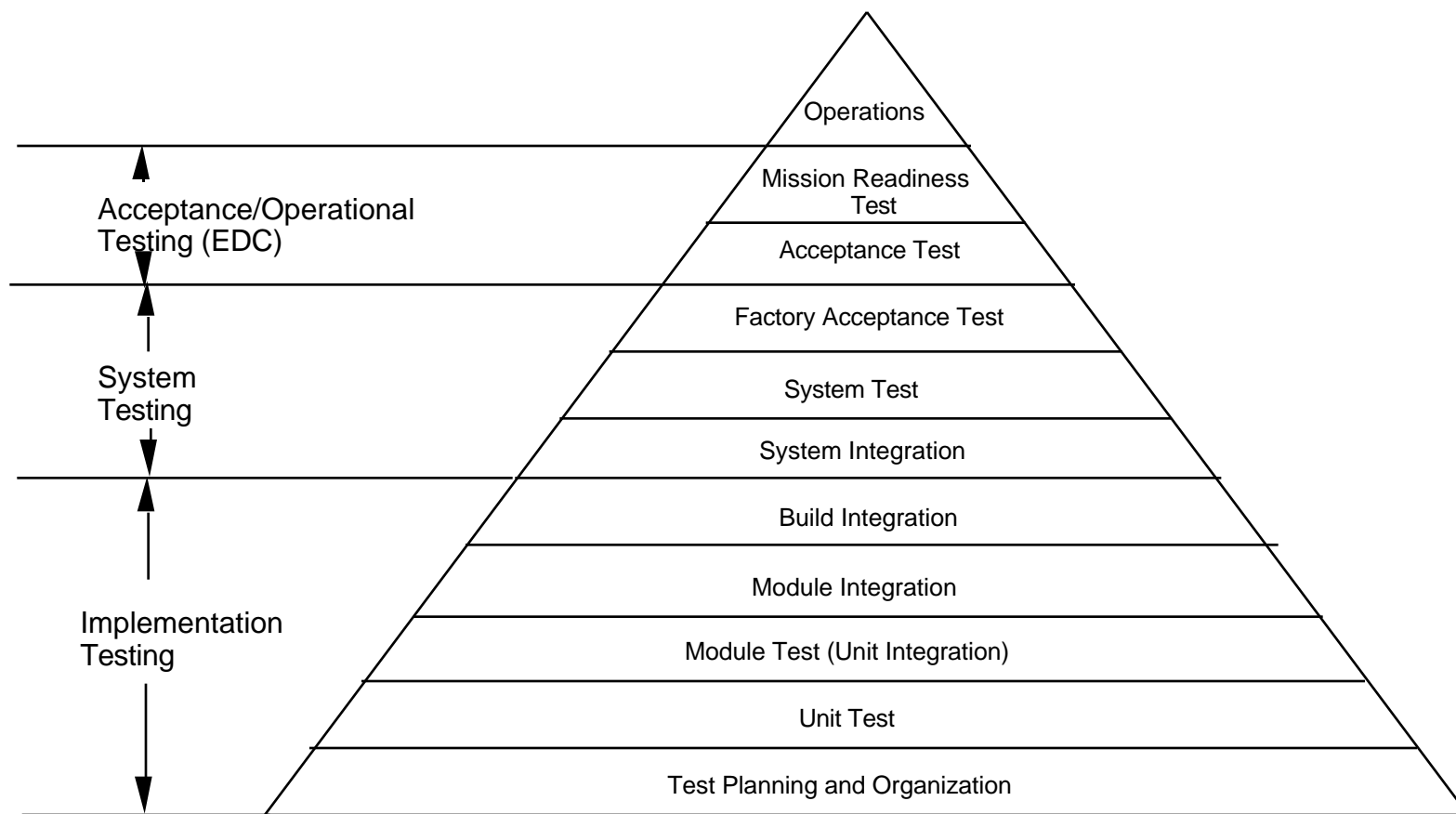
Prototype to mitigate risk

Purchased prototype system

- **run benchmarks**
- **determine optimum configuration**
- **gain familiarity with system**



Test Approach





Prototype/Benchmarks

Current results indicate processing can be performed at 7.5 Mbps:

- **CCSDS Frame synchronization**
- **BCH error detection and correction**
- **Band deinterleave**
- **Major frame synchronization**
- **Browse generation**
- **Automatic Cloud Cover Assessment**

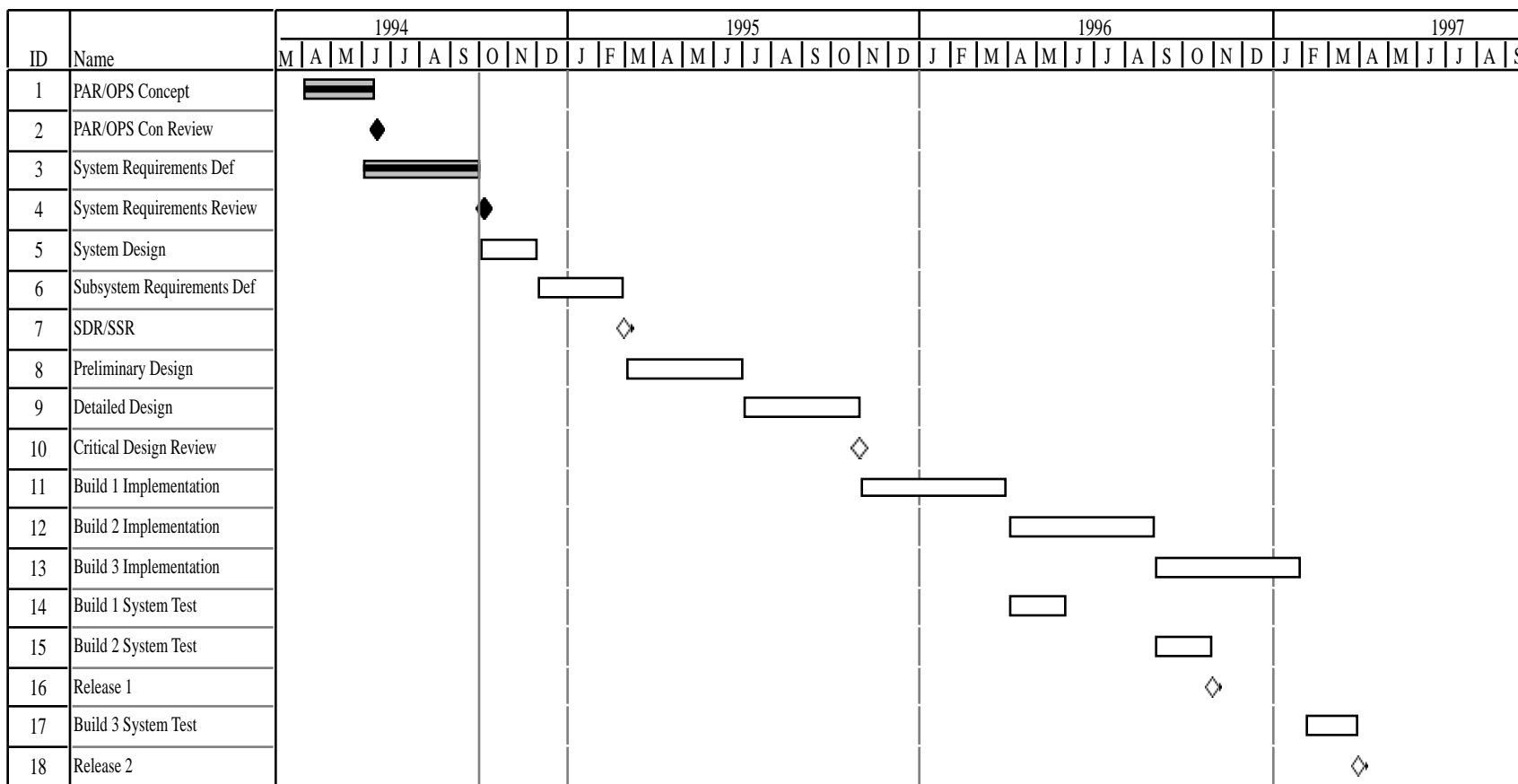
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Management Topics



Master Schedule for LPS



Civil Servant FTEs
Contractor FTEs

8 8 9 9 9 9 9 9
17 18 21 22 22 22 22 22

Landsat 7 Launch Readiness 5/98
Landsat 7 Launch Commit 12/98



Risk Analysis

- **Project Level 2 Requirements not currently baselined:**
 - **design of ETM+ instrument well defined**
 - **baselined version of Data Format Control Book**
 - **image data formats based on Landsat 4 & 5**

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RIDs

- **Please submit RIDs to: Phil Province (bldg 23, Rm C429, 286-7731) no later than October 20, 1994.**

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Rid Template

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Acronyms

Ao	Operational Availability	GByte	Gigabyte
AOS	Advanced Orbiting Systems	GSFC	Goddard Space Flight Center
ACCA	Automatic Cloud Cover Assessment	IAS	Image Assessment System
BCH	Bose-Chaudhuri-Hocquenghem	ID	Identification
BER	Bit Error Rate	IPD	Information Processing Division
CADU	Channel Access Data Unit	LCC	life-cycle cost
CCB	Configuration Control Board	LGS	Landsat 7 Ground Station
CCSDS	Consultative Committee on Space Data System	LPS	Landsat 7 Data Processing System
CRC	Cyclic Redundancy Check	LP DAAC	Land Processes Distributed Active Archive Center
CVCDU	Coded VCDU	LRU	Line Replaceable Unit
ECS	EOSDIS Core System	Mbps	megabits per second
EDC	EROS Data Center	MSCD	Mirror Scan Correction Data
EOSDIS	Earth Observation Data Information System	MDT	Mean Downtime
EROS	Earth Resources Observation System	MOC	Mission Operations Center
ESMO	Earth Science Mission Operations	MO&DSD	Mission Operations and Data Systems Directorate
ETM+	Enhanced Thematic Mapper Plus (instrument)	MTBF	mean time between failures
F&PR	Functional and Performance Requirements	MTTR	mean time to repair
F&PS	Functional and Performance Requirements	MTTRes	mean time to restore



NASA	National Aeronautics and Space Administration
NHB	NASA Handbook
PCD	Payload Correction Data
RMA	Reliability, Maintainability, and Availability
R-S	Reed-Solomon (error detection and correction scheme)
SMP	Systems Management Policy
SN	Space Network
STDN	Spaceflight Tracking and Data Network
TBD	To Be Defined/Determined
TBR	To Be Resolved
TByte	Terabyte
VCDU	Virtual Channel Data Unit
VCDU-ID	VCDU Identifier
WRS	Worldwide Reference System